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RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

DITCHING TESTS OF A $\frac{1}{24}$-SCALE MODEL OF THE LOCKHEED XR60-1 AIRPLANE

TED NO. NACA 235

By

Lloyd J. Fisher and Gibson A. Cederborg

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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DITCHING TESTS OF A $\frac{1}{24}$-SCALE MODEL OF THE LOCKHEED XR6O-1 AIRPLANE

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SUMMARY

The ditching characteristics of the Lockheed XR6O-1 airplane were determined by tests of a $\frac{1}{24}$-scale dynamic model in calm water at the Langley tank no. 2 monorail. Various landing attitudes, flap settings, speeds, and conditions of damage were investigated. The ditching behavior was evaluated from recordings of decelerations, length of runs, and motions of the model. Scale-strength bottoms and simulated crumpled bottoms were used to reproduce probable damage to the fuselage.

It was concluded that the airplane should be ditched at a landing attitude of about 5° with flaps full down. At this attitude, the maximum longitudinal deceleration should not exceed 2g and the landing run will be about three fuselage lengths. Damage to the fuselage will not be excessive and will be greatest near the point of initial contact with the water.

INTRODUCTION

An investigation of the probable ditching behavior and best ditching procedure for the Lockheed XR6O-1 airplane was made at the request of the Bureau of Aeronautics, Department of the Navy. This airplane, figure 1, is a large four-engine passenger and cargo transport.

The ditching characteristics of the XR6O-1 were determined from free-body landing tests of a dynamic model in calm water at the Langley tank no. 2 monorail. A $\frac{1}{24}$-scale model constructed at the Langley Laboratory was used. Design information regarding the airplane was furnished by the Lockheed Aircraft Corporation.

Previous NACA ditching tests with dynamic models have been made with structural damage to the fuselage simulated by removing various components of the bottom such as doors and hatches. This method is particularly applicable to bomber-type airplanes since they have large bomb-bay doors and numerous hatches that tend to be weaker than the rest of the bottom. It is not, however, suitable for transports like the XR60-1; consequently, novel methods were required for the present tests to simulate the probable fuselage damage.

APPARATUS AND PROCEDURE

Description of Model

The $\frac{1}{24}$-scale model had a wing span of 7.87 feet and a gross weight of 11.55 pounds. It was constructed principally of balsa wood and was ballasted internally to obtain scale weight and weight distribution about all axes. Photographs of the model are shown in figure 2.

The wing was constructed with a built-in slot in order to prevent high-attitude stalling. This type slot permitted the original wing contours to be maintained more closely than if a slat were placed in front of the leading edge.

The flaps were installed so that they could be held in the down position at approximately scale strength. A calibrated string was fastened between a special flap fitting and a corresponding wing fitting so that excessive water loads on the flap would cause the string to break and the flap to rotate on its hinges, thus simulating failure.

The permissible ditching loads on the bottom of the fuselage, furnished by the manufacturer, are shown in figure 3. From this information it was estimated that during a ditching the nose-wheel doors would be torn away completely, the bottom skin from station 288 to station 1477 would be damaged, but that the cargo floor and fuselage above it would not be damaged.

The probable damage influencing the ditching behavior was simulated on the model by various means. The almost certain failure of the nose-wheel doors was reproduced by removing them entirely. The unknown damage of the remaining bottom was allowed for by constructing the model with a detachable fuselage bottom below the cargo floor from station 288 to station 1477 so that the original bottom could be replaced with special test bottoms. Approximate scale-strength sections designed and tested to break under a uniformly distributed load of 5 psi (full scale) were used. These sections shown in figure 4 consisted of a skeleton framework of balsa wood covered with thin waterproof paper. They were intended to indicate the regions at which bottom failure would be most likely to occur and to supply the appropriate effects on behavior by sustaining damage similar to that which the airplane would sustain. It was necessary to install a new bottom after each ditching. Since it was recognized that the paper bottom probably would not deform exactly as the metal bottom of the airplane, a simulated crumpled bottom made of solid balsa wood, figure 5, was also tested. The crumpled bottom simulated the shape that the fuselage might take if the bulkheads below the cargo floor failed allowing the skin to be crumpled against the floor but not severely torn.

Test Methods and Equipment

The model was launched by the catapult on the tank no. 2 monorail so that it was free to glide onto the water. The model left the launching carriage at scale speed and at the desired landing attitude, and the control surfaces were set so that the attitude did not change appreciably in flight. The ditching behavior was evaluated from visual observation, longitudinal-deceleration records, and motion-picture records. The decelerations were measured with a small time-history accelerometer placed inside the model near the pilot's enclosure.

Test Conditions

(All values given refer to the full-scale airplane.)

Gross weight.- The gross weight corresponded to 160,000 pounds.

Center of gravity.- The center of gravity was located at 40.8 percent of the mean aerodynamic chord and 2.4 inches below the fuselage reference line.

Attitude.- Attitude is defined as the angle between the fuselage reference line and the water surface. The three attitudes used in the tests were 9° (near stall), 5° (intermediate), and 1° (near level).

Flaps.- Tests were made with the flaps up and full down. The full-down flaps were tested at the scale breaking strength of 37,500 pounds, furnished by the manufacturer.

Landing speeds.- Using the previously chosen values of attitude, flap setting and weight, the landing speeds were calculated from power-off lift curves and are given in table I.

Landing gear.- No landing gear was provided on the model and all tests simulated ditchings with the landing gear retracted.

Conditions of damage.- The following conditions of damage were used in the tests:

(a) No simulated damage

(b) Simulated failure of the nose-wheel doors and simulated crumpling of the fuselage bottom from station 288 to station 1477

(c) Simulated failure of the nose-wheel doors and a scale-strength bottom from station 288 to station 1477

RESULTS AND DISCUSSION

General

A summary of the results of the tests is presented in table I. The symbols used in table I to describe the motion of the model are defined as follows:

b deep run - a run in which the model travels through the water partially submerged and exhibits a tendency to dive although the attitude of the model is nearly level

d slight dive - a dive in which the angle between the water surface and fuselage reference line is about 10°

h smooth run - a run in which there is no apparent oscillation about any axis and during which the model settles into the water as the forward velocity decreases

u trimmed up - a run in which the attitude of the model increases after contact with the water

Time-history curves of longitudinal deceleration, attitude, horizontal displacement, and vertical displacement are given in figures 6, 7, and 8. Sequence photographs showing characteristic behaviors of the model are shown in figure 9. Figure 10 contains photographs showing the ditching damage sustained by the scale-strength bottoms.

Effect of Damage

The model with no damage made smooth runs. With simulated failure of the nose-wheel doors and a simulated crumpled bottom, the model ran deeply at the 9° attitude, ran smoothly at the 5° attitude, and dived slightly at the 1° attitude. With simulated failure of the nose-wheel doors and a scale-strength bottom, the model made deep runs with occasional smooth runs at the 5° attitude.

There was a tendency for the model with either undamaged bottom or crumpled bottom to trim up after contact. (See figs. 7 and 9.) This tendency appears to be one of the reasons for the smooth runs obtained with the undamaged bottom and sometimes obtained with the crumpled bottom.

The scale-strength bottoms generally did not sustain severe damage and the major damage usually occurred near the point where the bottom first touched the water. (See fig. 10.) The damage sustained by the scale-strength bottoms is thought to be similar to that occurring in ditchings of airplanes of similar type and fuselage strength. There was little tendency for the model to trim up with this damage.

Neither the motions of the model nor the amount of damage obtained in the tests indicates very violent ditching behavior. Of the three damage conditions tested, the scale-strength condition gave results that may be considered most typical of a full-scale ditching. On the basis of the motions and damage obtained with the scale-strength bottom it appears likely that the cargo floor will not fail and that the interior of the airplane will be relatively safe in a ditching.

Effect of Attitude

Table I shows that with either scale strength or crumpled bottom, both of which are representative of the damage that may occur in a full-scale ditching, the best behavior was obtained at the 5° attitude. The maximum deceleration in a ditching made at 5° attitude did not exceed 2g. (See fig. 7.) The worst behavior occurred at the 1° attitude.

Effect of Flaps

When neither of the scale-strength flaps failed, they introduced a nose-down moment that caused the model to run deeply and make a short run. Usually, however, at least one flap failed and quite often both flaps failed; in either case there was no discernable nose-down moment. Since the flaps will probably fail and an appreciable speed reduction can be obtained with extended flaps, the airplane should be ditched with full-down flaps.

CONCLUSIONS

From the results of the model tests the following conclusions may be drawn:

1. The airplane should be ditched at a landing attitude of about 5° with flaps full down.

2. When ditched as recommended, the maximum longitudinal deceleration should not exceed 2g and the landing run will be about three fuselage lengths.

3. Damage to the fuselage will not be excessive and will be greatest at the point of initial contact with the water.

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TABLE I.- SUMMARY OF RESULTS OF DITCHING TESTS IN CALM WATER OF A $\frac{1}{24}$-SCALE MODEL OF THE LOCKHEED XR60-1 AIRPLANE

[All values are full scale; gross weight, 160,000 pounds]

Landing attitude, deg		9						5						1		
Landing speed, mph		83			111			91			132			104		
Condition of damage	Behavior[1] / Flaps	Max	Run	Mo	Max	Run	Mo	Max	Run	Mo	Max	Run	Mo	Max	Run	Mo
No simulated damage	Up				1.0	4	h				2.1	5	h			
	Full down	1.0	3	h				0.7	3	uh				0.9	3	uh
Simulated failure of the nose-wheel doors and a simulated crumpled bottom from station 288 to station 1477	Full down	1.0	3	b				0.8 0.8	3 3	h uh				4.0	1	d
Simulated failure of the nose-wheel doors and a scale-strength bottom from station 288 to station 1477	Full down	2.2	2	b				2.0 2.0	2 2	b h				2.3	2	b

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[1]Behavior

Max - maximum longitudinal deceleration, given in multiples of the acceleration of gravity
Run - length of landing run, given in multiples of the length of the airplane
Mo - motion of the model, denoted by the following symbols:
- b - ran deeply
- d - dived slightly
- h - ran smoothly
- u - trimmed up

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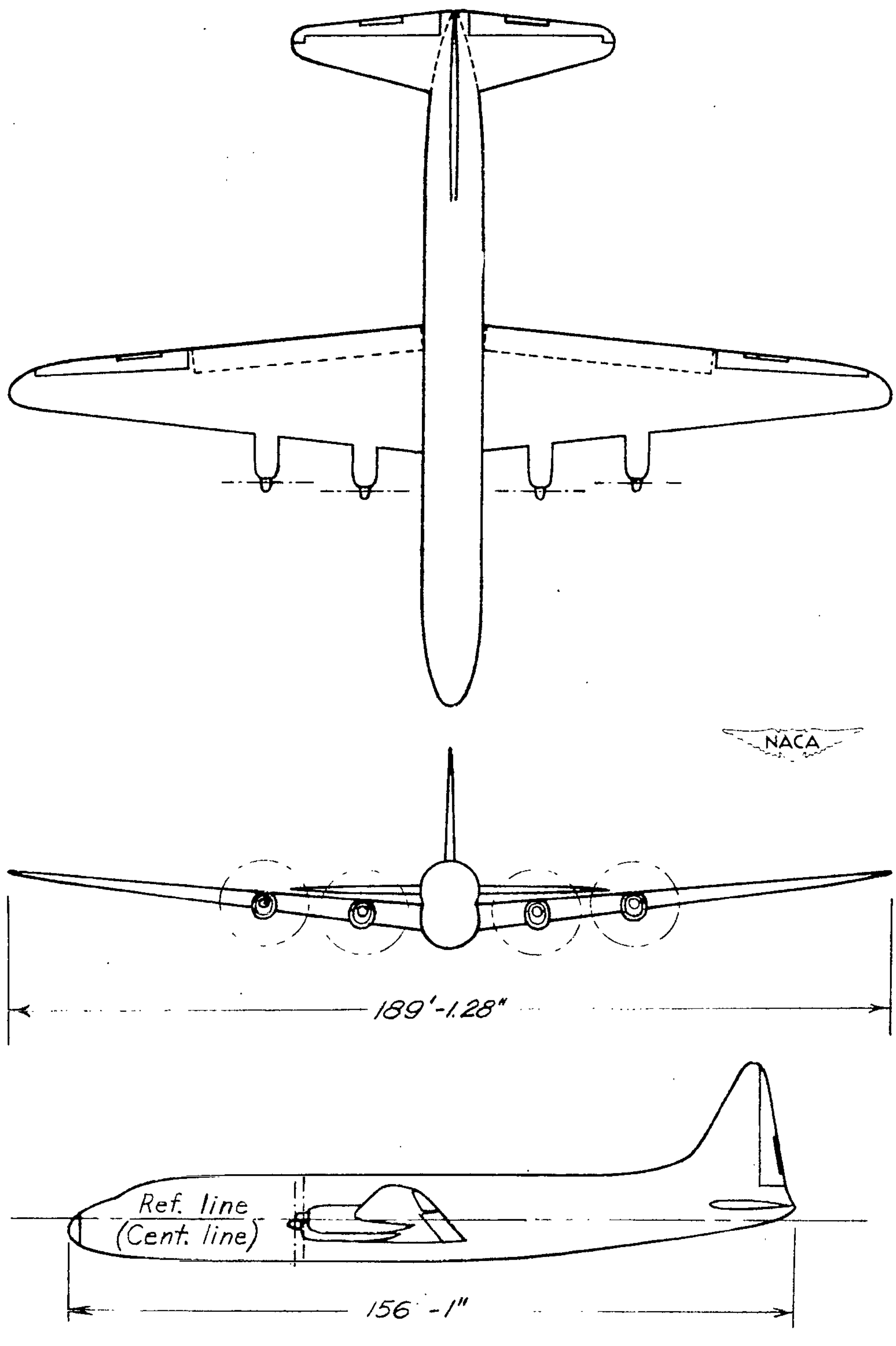

Figure 1.- Three-view drawing of the Lockheed XR60-1 airplane.

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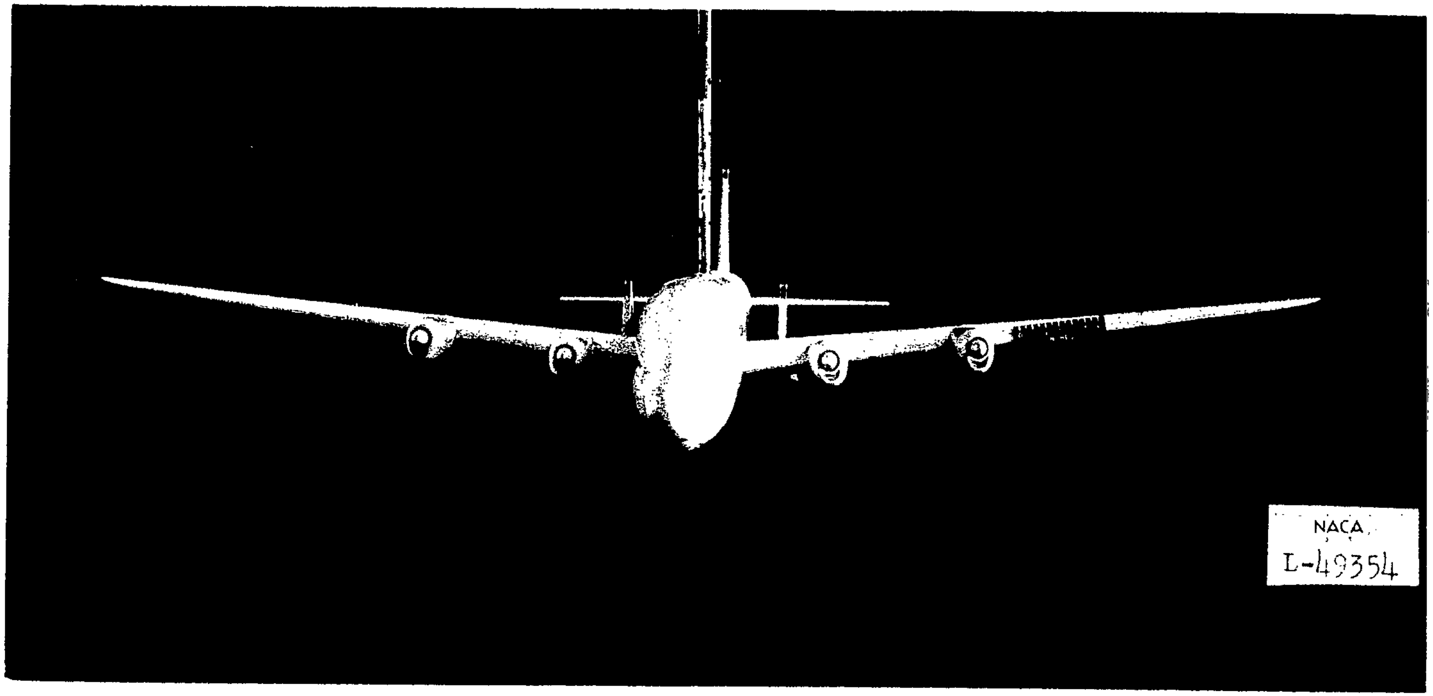

(a) Front view.

Figure 2.- The model with no simulated damage.

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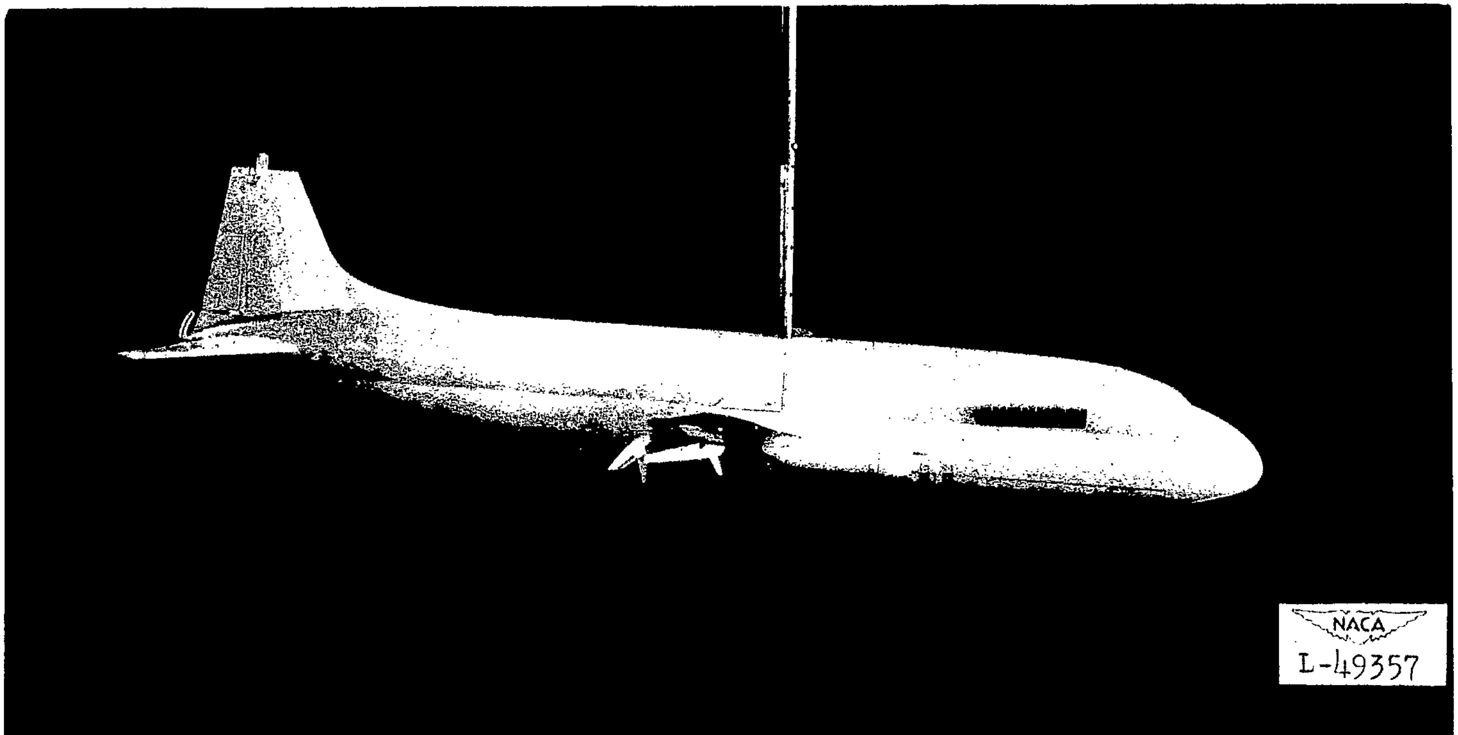

(b) Side view.

Figure 2.- Continued.

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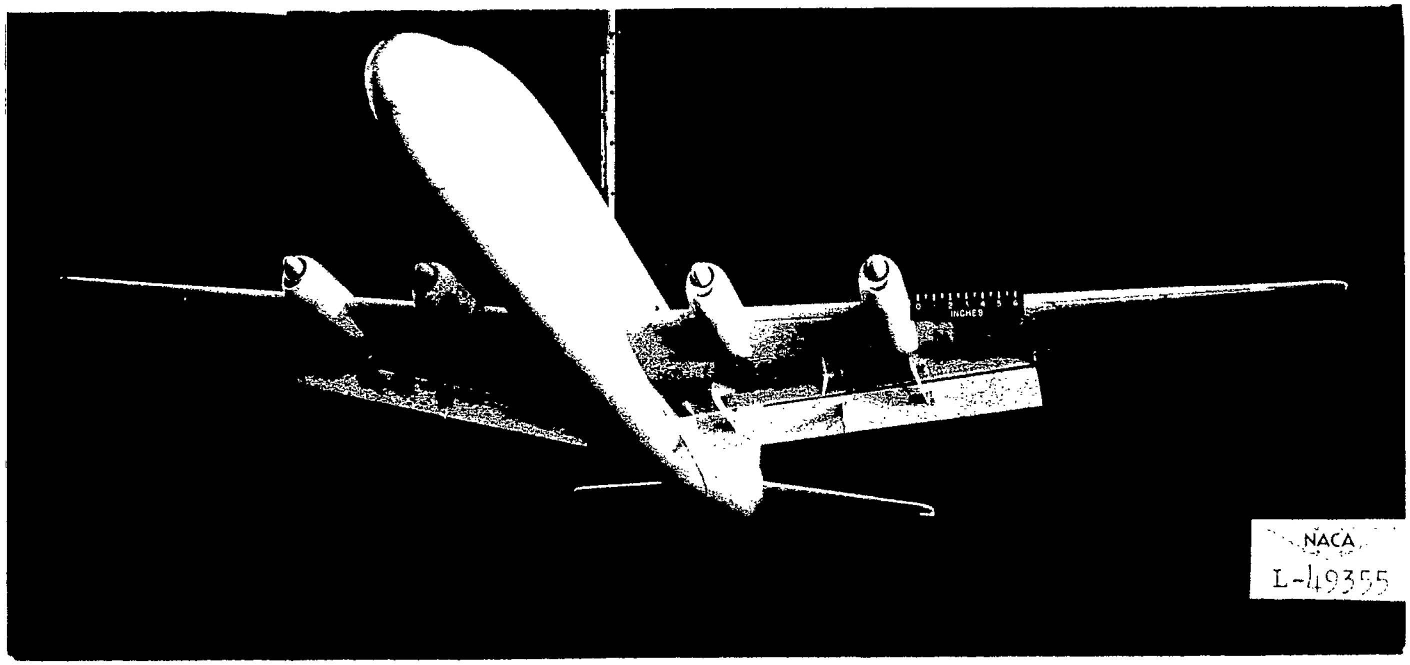

(c) Three-quarter bottom view.

Figure 2.- Concluded.

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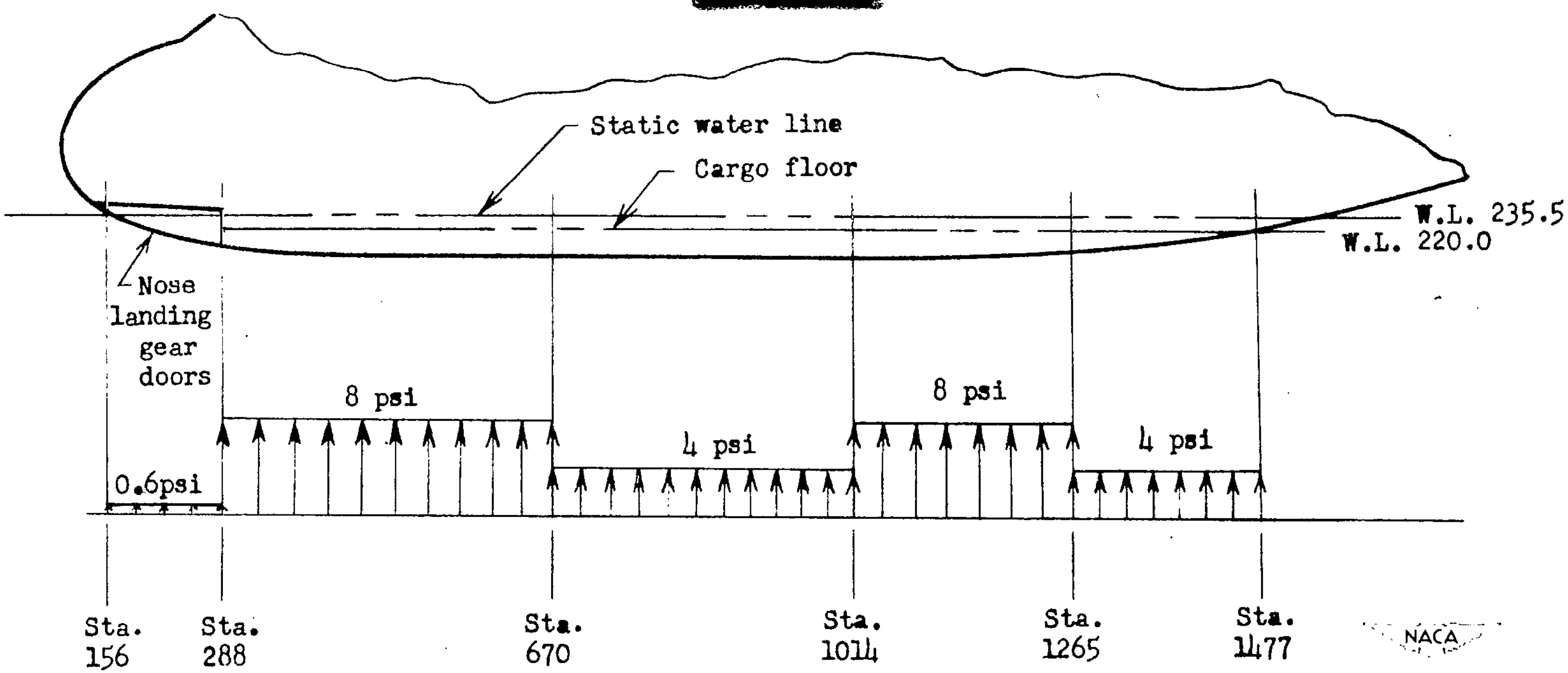

Figure 3.- Permissible water loads (ditching) on bottom of fuselage.

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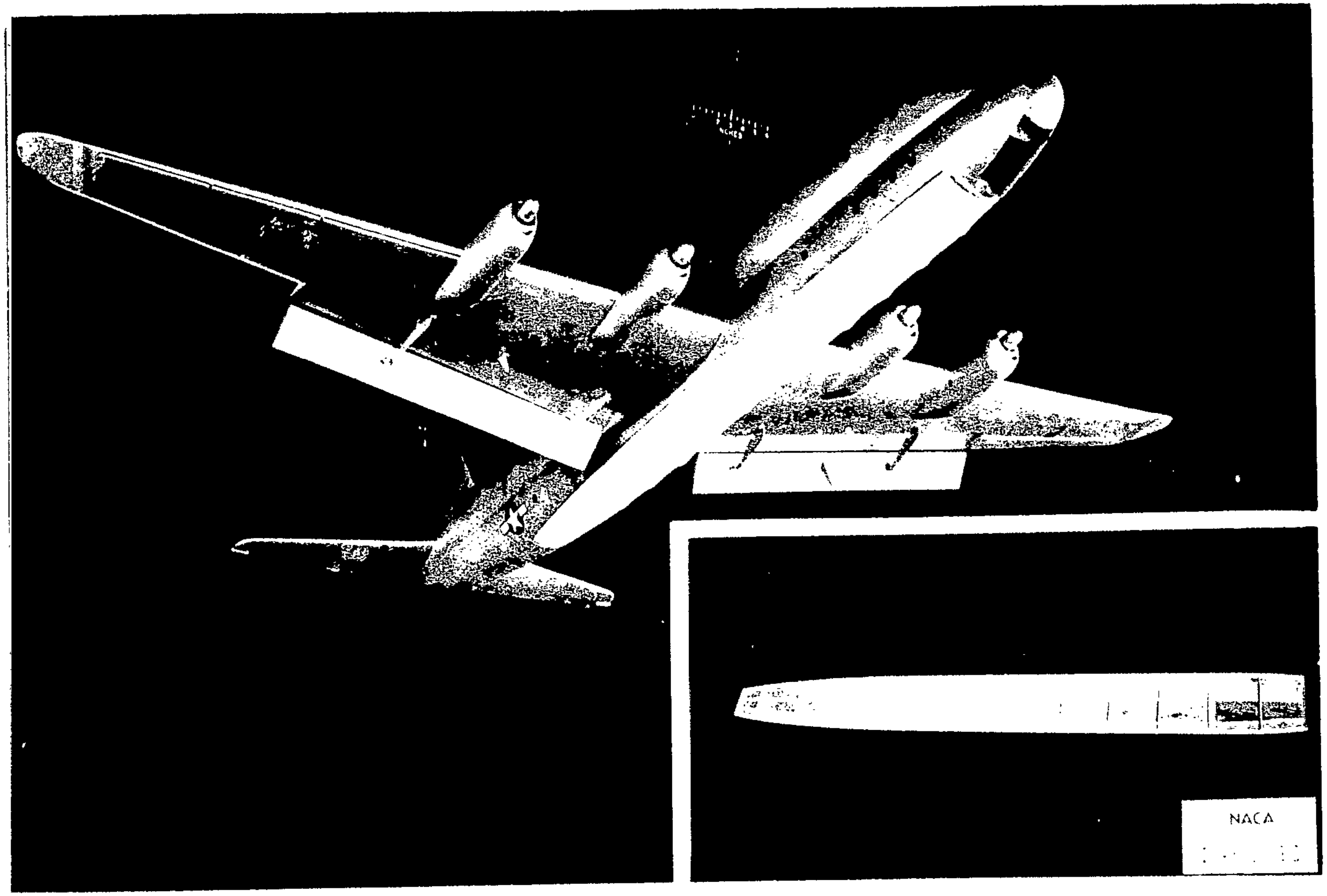

Figure 4.- Simulated failure of the nose-wheel doors and a scale-strength bottom. Insert shows the structure of the scale-strength bottom.

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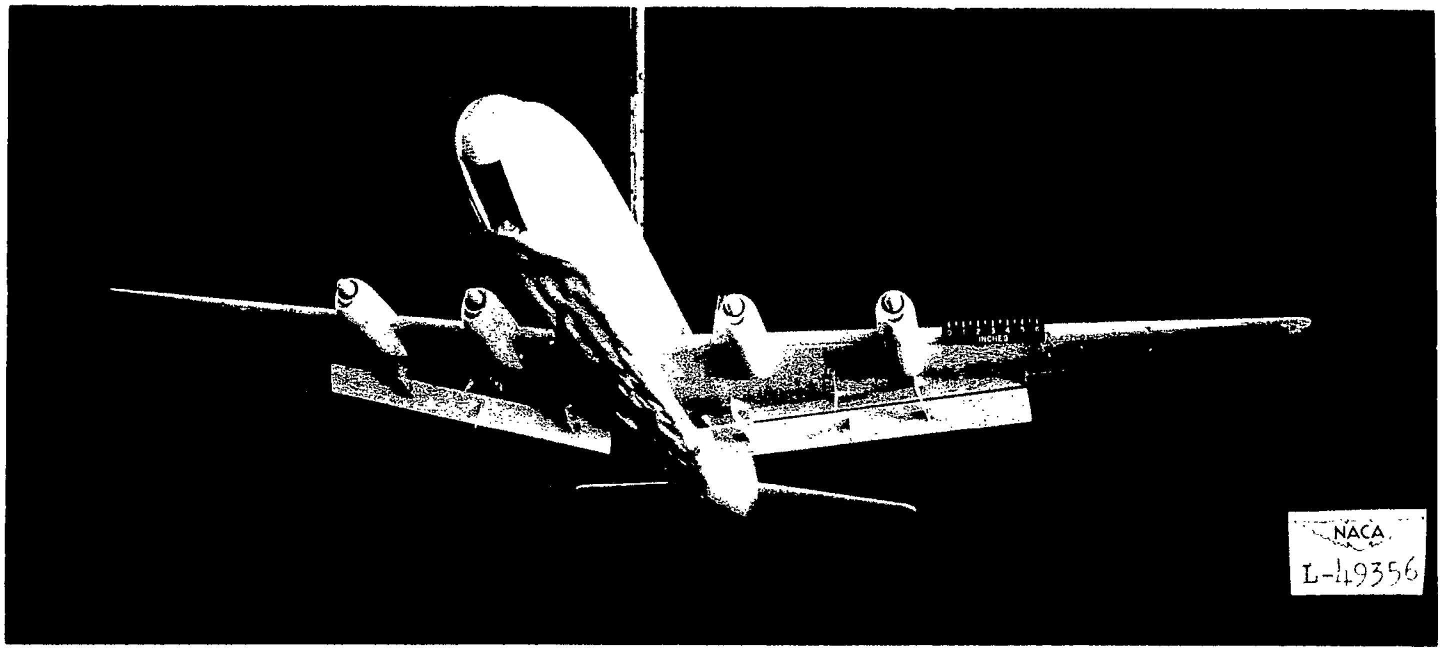

Figure 5.- Simulated failure of the nose-wheel doors and simulated crumpling of the fuselage bottom.

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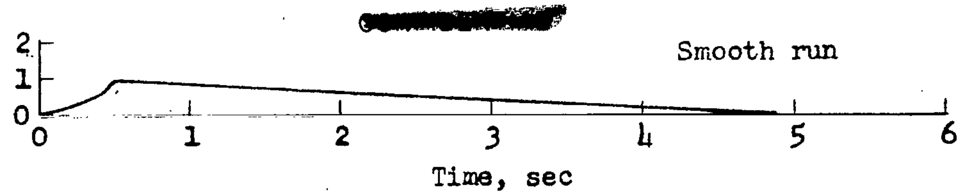
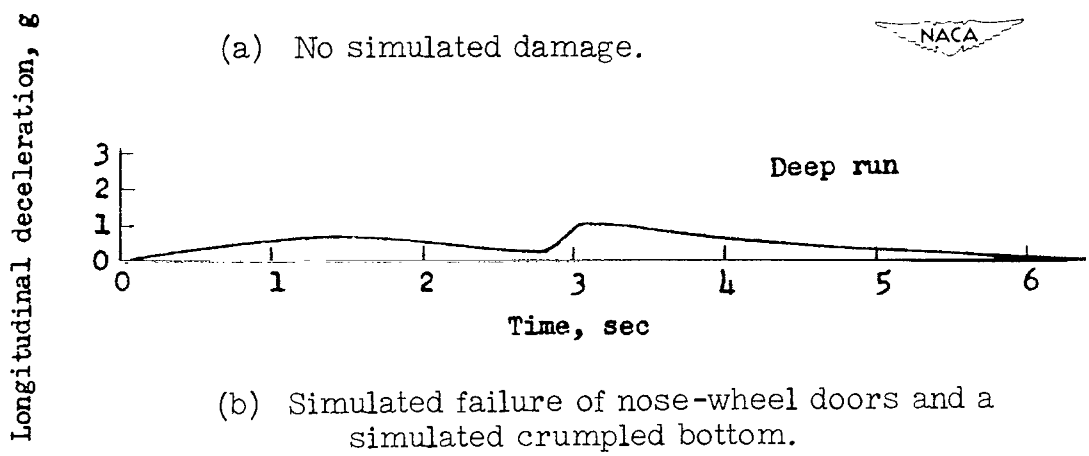
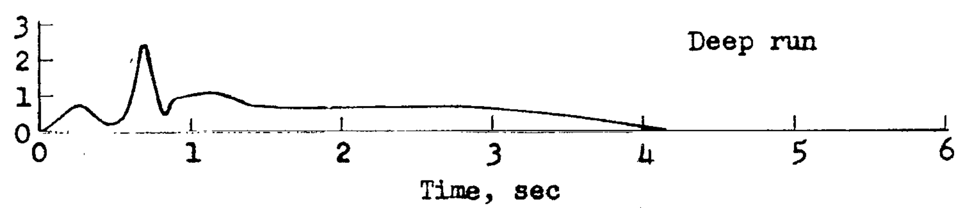


(a) No simulated damage.



(b) Simulated failure of nose-wheel doors and a simulated crumpled bottom.



(c) Simulated failure of nose-wheel doors and a scale-strength bottom.

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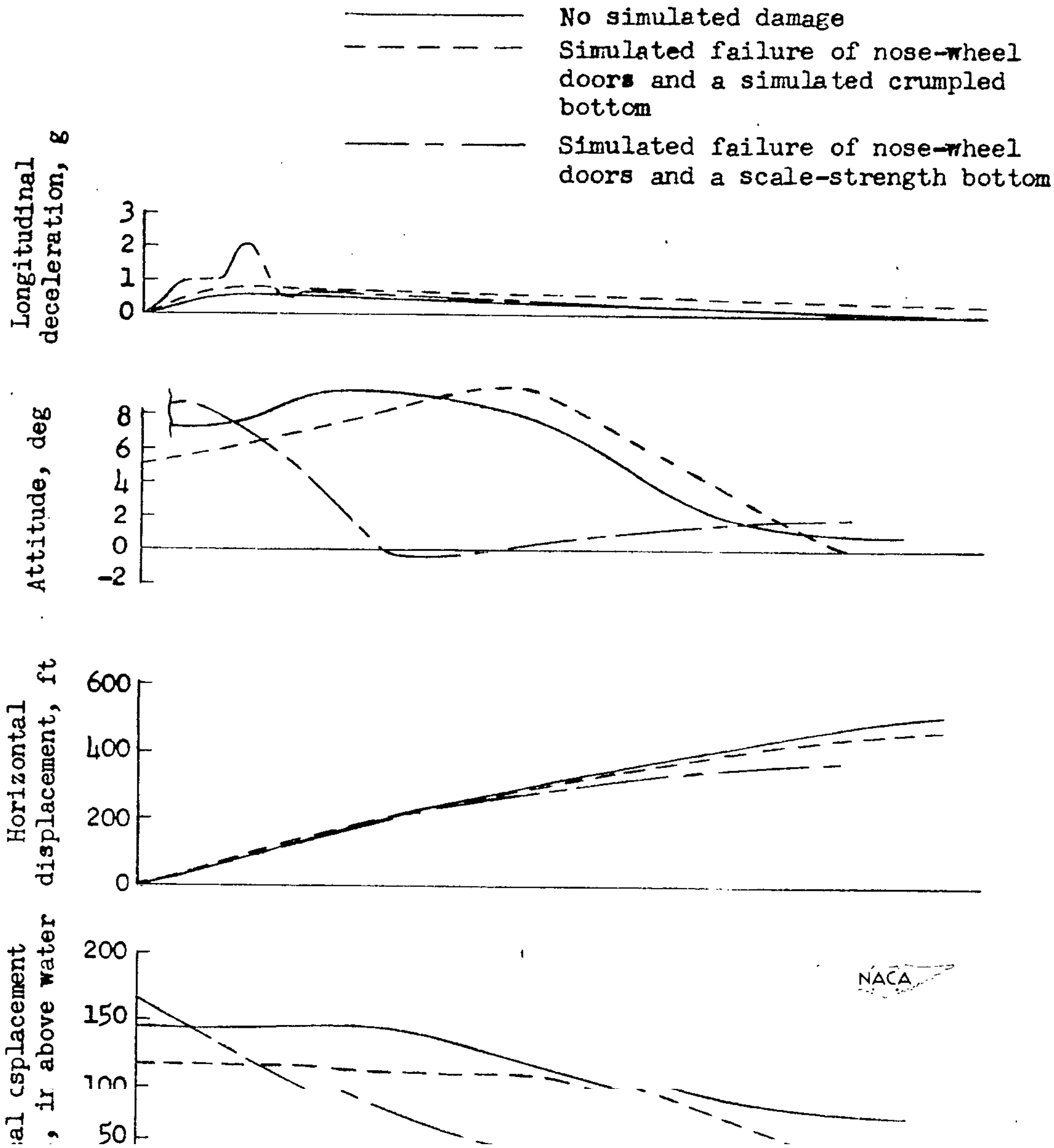
No simulated damage
Simulated failure of nose-wheel doors and a simulated crumpled bottom
Simulated failure of nose-wheel doors and a scale-strength bottom
Longitudinal deceleration, g
3
2
1
0
Attitude, deg
8
6
4
2
0
-2
Horizontal displacement, ft
600
400
200
0
above water
200
150
100
50
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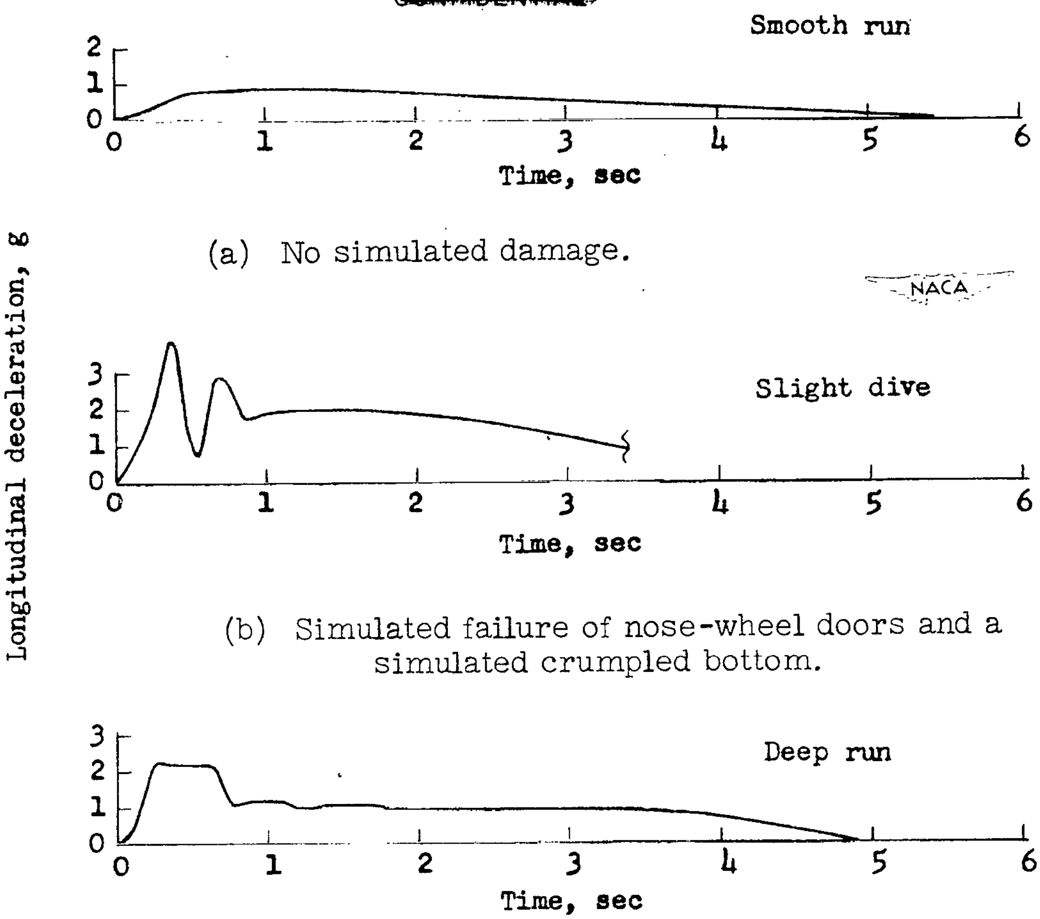

(a) No simulated damage.

(b) Simulated failure of nose-wheel doors and a simulated crumpled bottom.

(c) Simulated failure of nose-wheel doors and a scale-strength bottom.

Figure 8.– Typical curves of longitudinal deceleration. Landing

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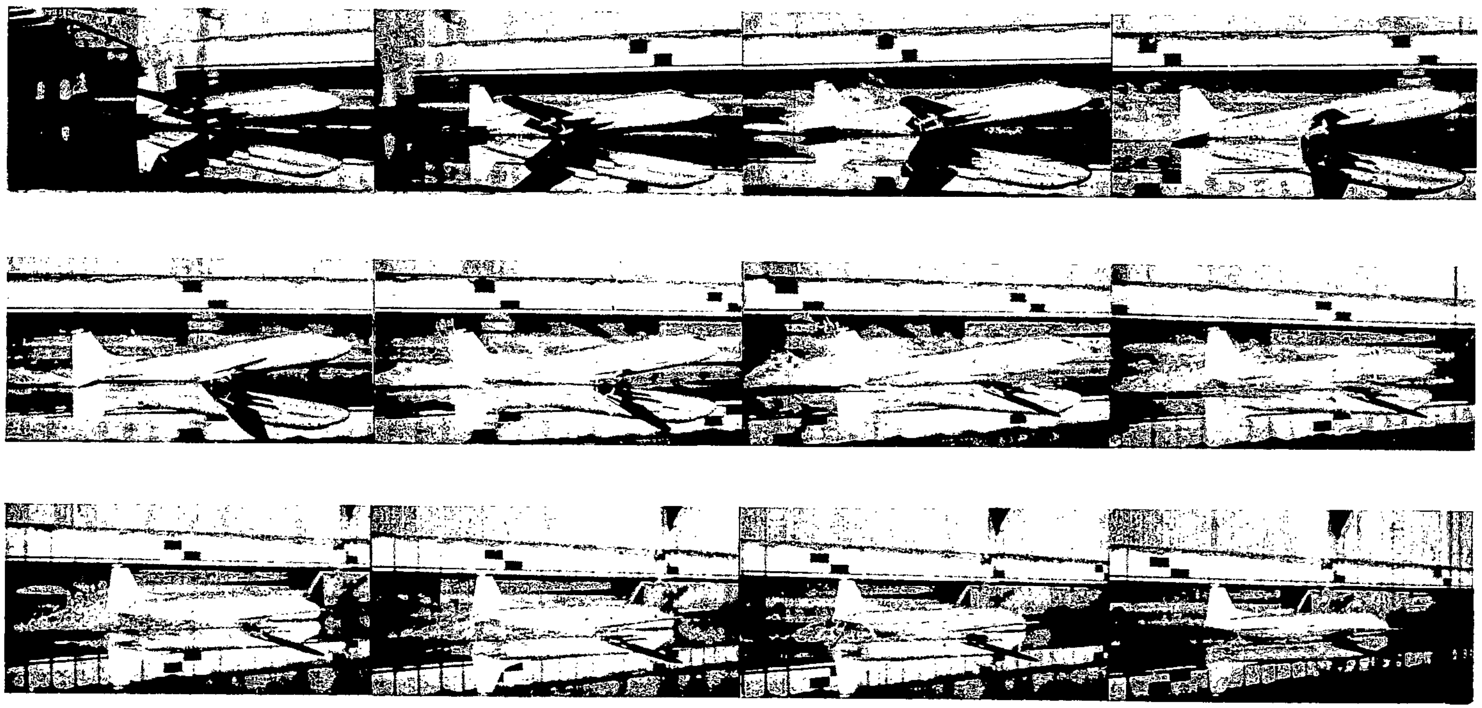

(a) No simulated damage.

Figure 9.- Sequence photographs at 0.61-second intervals. Landing attitude is 5°; flaps are full down; landing speed is 91 mph. All values are full scale.

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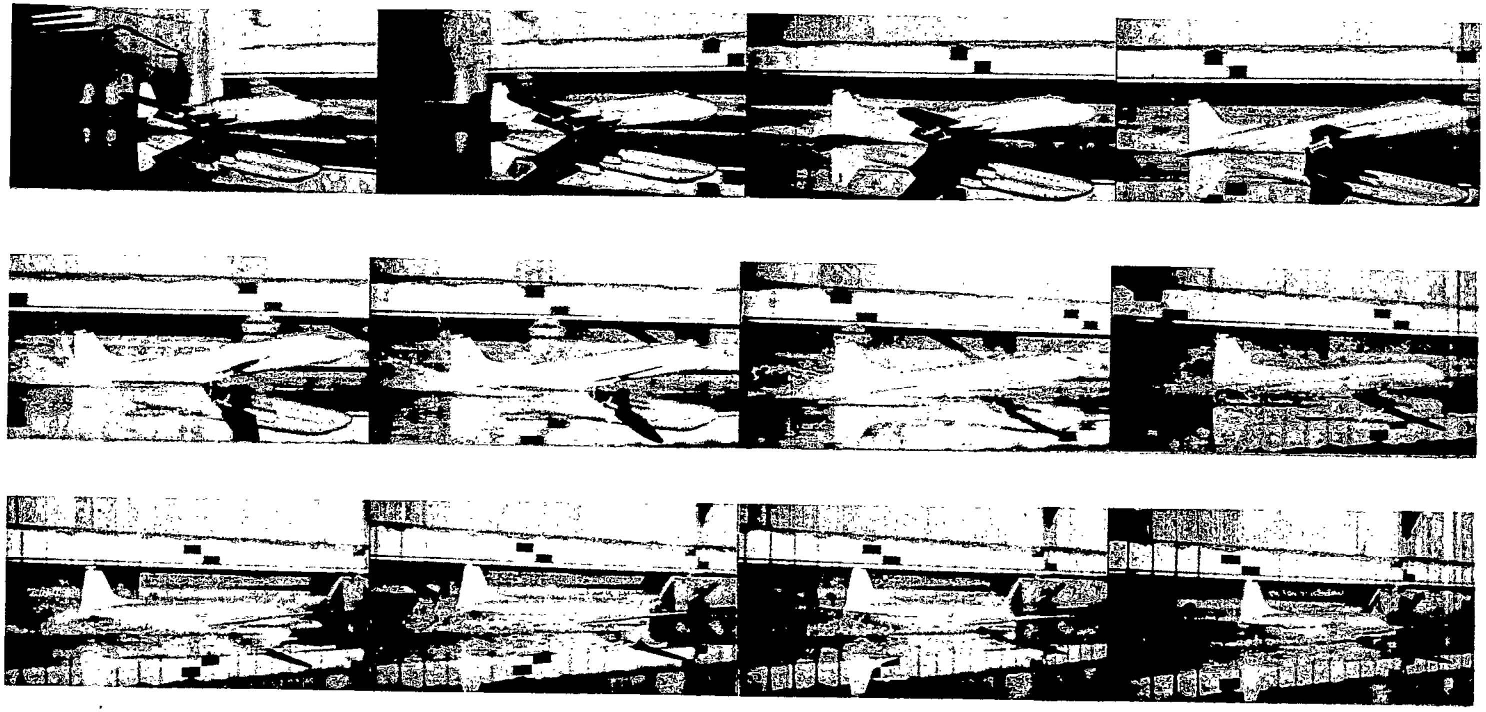

(b) Simulated failure of the nose-wheel doors and a simulated crumpled bottom.

Figure 9.- Continued.

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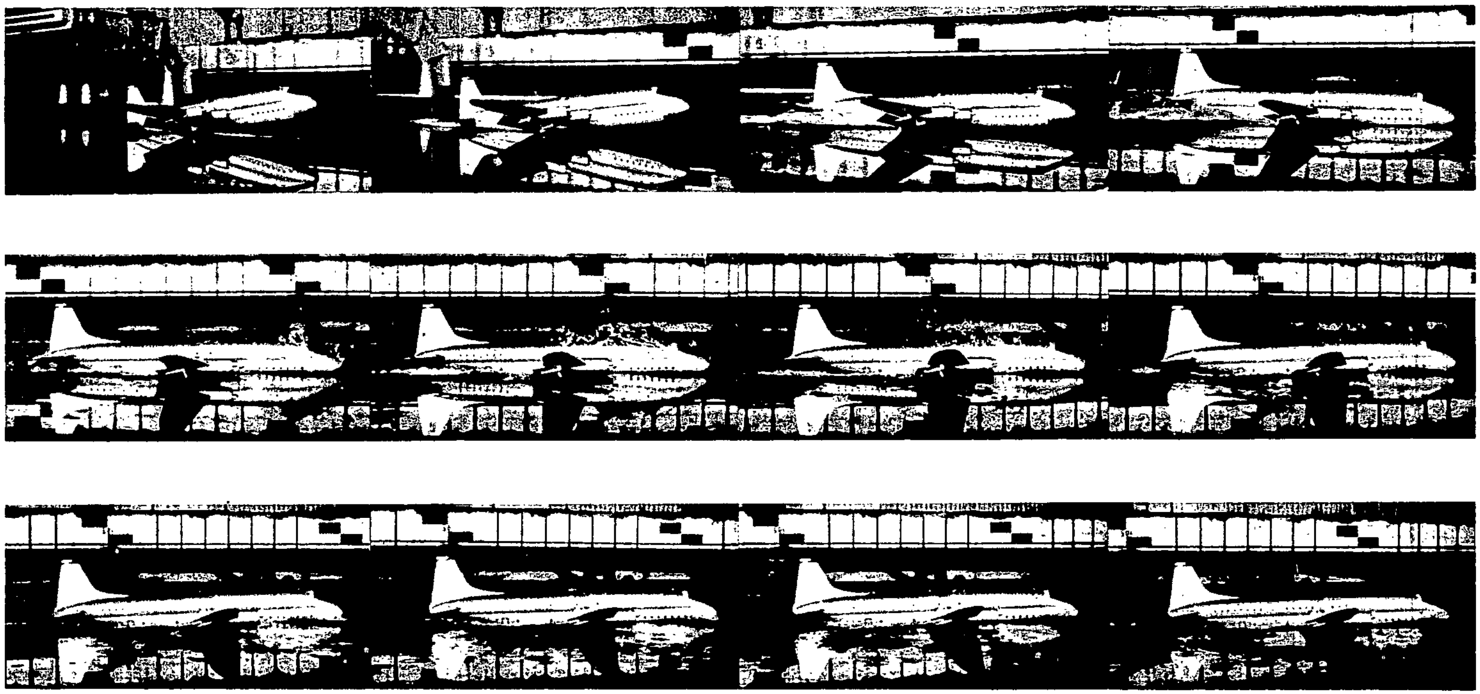

(c) Simulated failure of the nose-wheel doors and a scale-strength bottom.

Figure 9.- Concluded.

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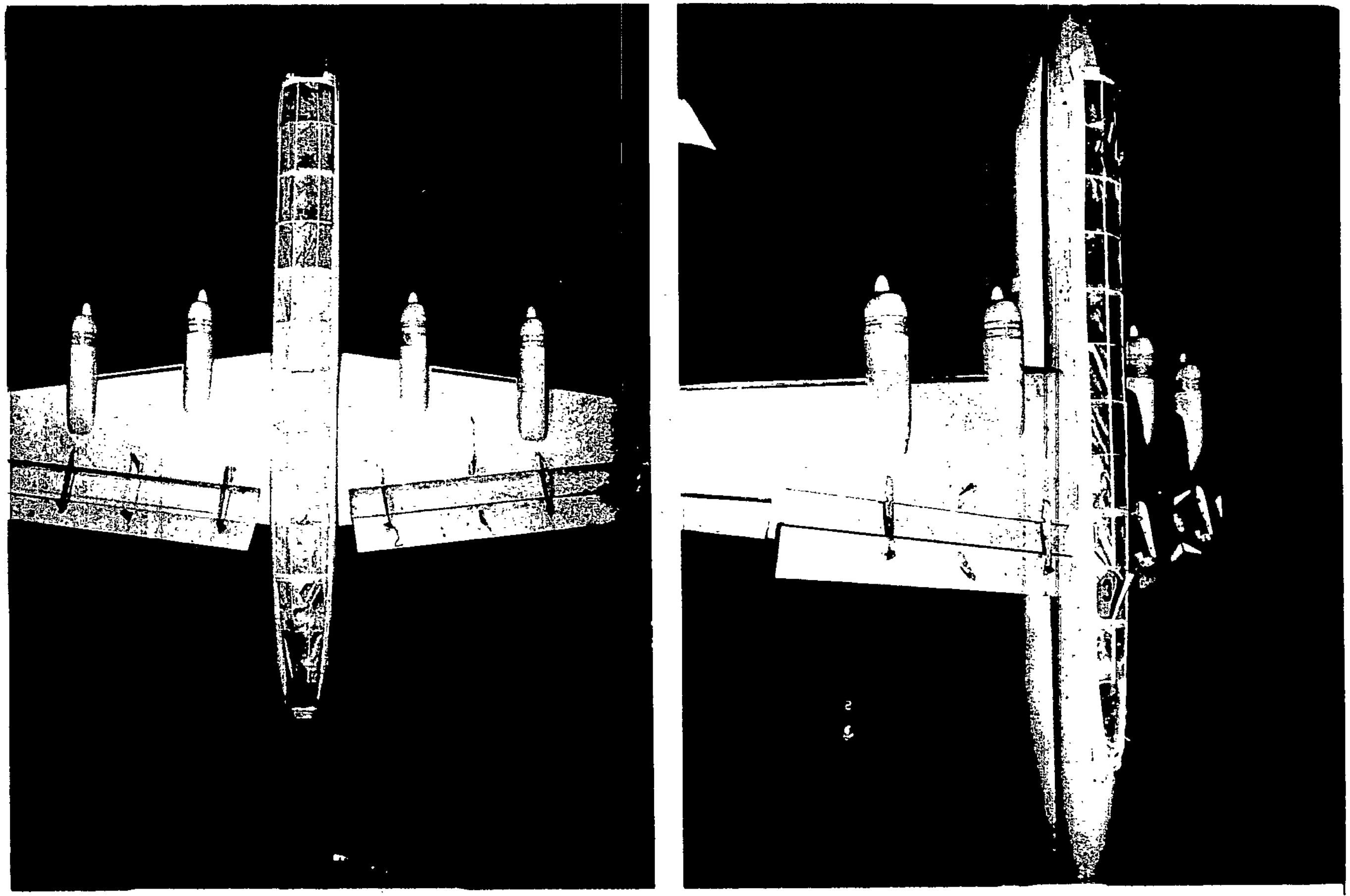

(a) Two ditchings at 9° landing attitude, flaps full down, 83 mph landing speed.

Figure 10.- Damage sustained by the scale-strength bottoms. All values are full scale.

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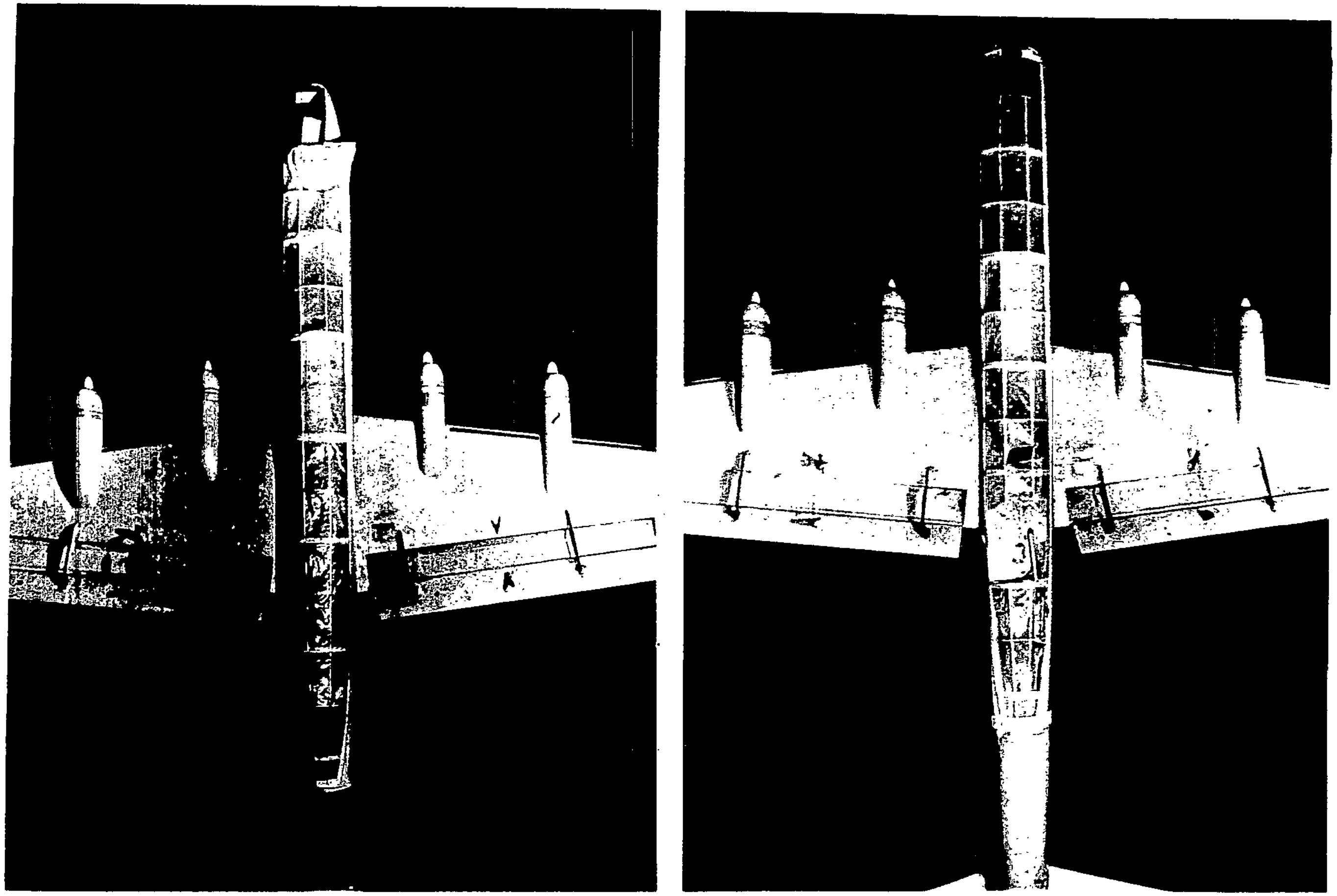

(b) Two ditchings at 5° landing attitude, flaps full down, 91 mph landing speed.

Figure 10.- Continued.

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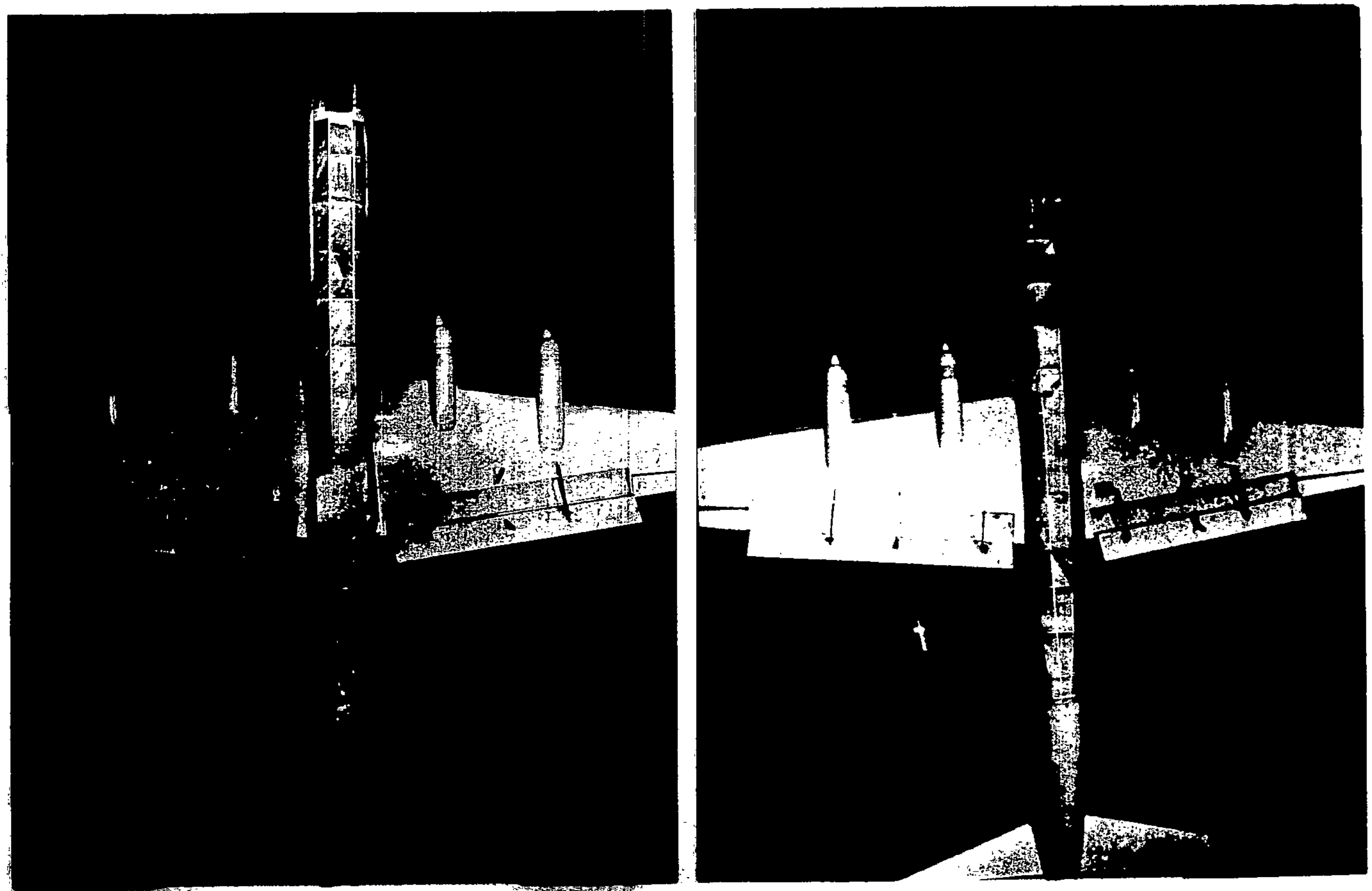

(c) Two ditchings at 1° landing attitude, flaps full down, 104 mph landing speed.

Figure 10.- Concluded.